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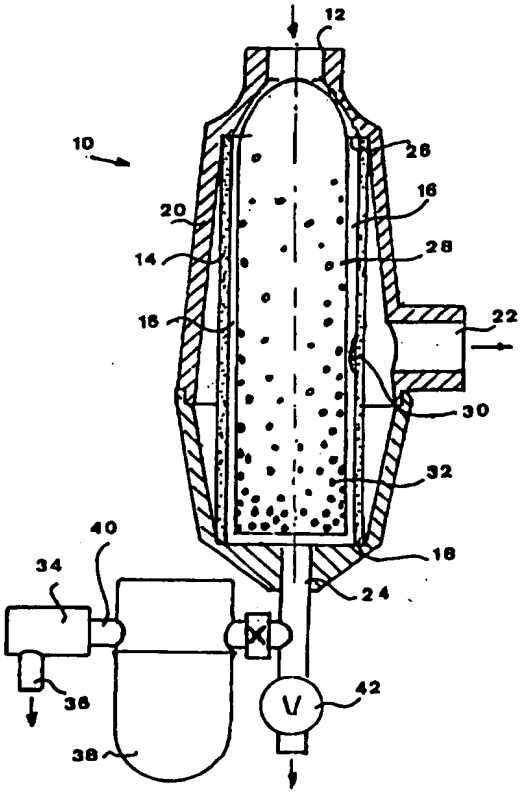
(54) Title: FILTER

(57) Abstract

The invention provides a clog resistant filter (10) for separating solids from liquids. The filter (10) has a hollow filter element (14) with an inlet (12) communicating with the hollow inside of the filter (10) and a first outlet (22) for filtrate and a second outlet (24) for liquid containing a high concentration of solids. A volume reduction device (28) is inserted into the hollow filter on the prefilt side and the volume reduction device is provided with a turbulence creating outer surface (32).



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FILTER

The present invention relates to a filtration apparatus and a method for the separation of a fluid-solids mixture. More particularly, the invention provides means to allow a filtration process to continue for long periods, without clogging, by removing solids, including those of a biological composition, from the filter medium by turbulent flow and discharging these solids entrained in a small quantity of liquid and by periodic flushing.

Filtration processes are widely used in industrial, chemical, municipal and agricultural systems. With the increasing adoption of drip-irrigation methods in agriculture, there has arisen a demand for better filtration of irrigation water. Improved filtration is essential for the satisfactory operation of drip-irrigation tubes, as these include fine passages and the clogging thereof with solid particles will result in failed crops. While in industrial environments a preventive maintenance program will include regular filter cleaning, in agriculture filters are likely to be widely dispersed and less likely to be serviced. Such conditions call for a filter unit of the type which can operate reliably for long periods without servicing.

In some types of liquid filters, the input stream requiring filtration is directed to flow parallel to and along the face of the filter element through which it is passed in order to produce a filtrate of desired quality. As a result, some or most of the solids which are retained by the filtering process are swept to the far end of the filter, where they tend to accumulate. Deflectors are known which may be placed so as to increase

the speed and force of the incoming parallel flow stream, and consequently its washing action.

The solid material retained inside the filter element and driven to the far end of the filter is not completely at rest. A backflow caused by local turbulence may return retained solids upstream. Thus, even if the washing action initially prevents or delays blockage of the filter screen, a gradual increase in concentration of material in the vicinity of the latter increases the probability of eventual deposition of retentions on the screen and of them being forced into or even out through the screen orifices. This may lead to a gradual loss of output pressure and flow and a need to clean the filter element. The necessity to clean the filter may be delayed by periodic flushing out of the accumulated retentions through a manual or automatic flushing valve. Also, deposits on the proximal wall of the filter element may be loosened by hydraulic shock and by the increased flow caused by valve opening. However, under difficult conditions such flushing does not prevent relatively rapid clogging of the filter.

In US Patent No. 3,862,035 the present inventor disclosed a means to minimize accumulation of free or deposited solids in a filter by continually removing them without interrupting liquid flow through the filter, thus reducing costs associated with regular maintenance, with pressure loss, with filter shut-down and investment in backup filtration. Generally, the latter invention comprised pressure-reducing means ("bleed") in communication with the filter body, or within the latter, said bleed continuously discharging a small portion of the liquid flowing through the filter, together with solids retained by the filter element at a

pressure substantially less than that within the filter, while the energy made available by the pressure reduction was either to be dissipated by means of the friction provided by the discharge path, or by using such energy for operating a hydraulic device placed within or without the filter.

Various embodiments of the invention have greatly increased the working cycle of filters and improved quality of filtration by lessening eventual penetration of solids previously retained through the orifices of the filter screen, whether smaller than or similar in size to the orifices, and of larger particles worn down by repeated turbulence-induced particle-particle and particle-filter impact. Despite the benefits provided by the latter invention, clogging and eventual blockage of the screen could still be caused by indeterminate movement of particles close to the filter screen at its far end, by turbulent return of some retentions upstream in the filter and by a particularly heavy concentration of or by sudden spurts of solids in the incoming stream. Increasing discharge flow through the bleed means, in order to cope with the latter, is sometimes not practical or economically efficient.

In US Patent No. 4,966,701 (and its division, U.S. Patent No. 5,076,942) the present inventor presented a simple and cost-effective answer to the problems described. It provides a static volume reduction device which is disposed in such a manner and which is of such a shape designed to minimize the volume of unfiltered liquid within the filter housing and, in particular, between the filtering side of the filter element and the wall of the device.

In conjunction with periodic operation of the manual or automatic flushing valve provided by the invention and the pressure-reducing discharge means, superior filtration and a greatly lengthened working cycle are achieved. In most conditions, operation of the volume reducing device considerably improves the effectiveness for cleaning of the hydraulic shock and of the added drag that is caused by the sudden increase in speed of the incoming liquid flow along the screen after opening the flushing valve.

In general, the integration of volume reduction device (VRD) with continual discharge through pressure reducing means and blow-out flushing as needed, as described in said U.S. Patents, is most effective, resulting often in working cycles of weeks, or even months without having to cease filtration. Alternatively, the invention may be exploited primarily to reduce to a minimum the amount of continuously discharged liquid.

Despite the general effectiveness of the inventions referred to above, a considerable proportion of material of biological origin in the liquid to be filtered presents a specific challenge to the filter, regardless of whether the material is natural or industrial in origin. This may be caused by the composition, shape, pliability or surface characteristics (such as stickiness) of biological particles or substances (such as mucoid exudations), or a combination of the latter alone, or in interaction with inorganic substances present in the liquid.

Such materials and interactions can lead to rapid clogging of any kind of filter screen, whatever the construction or shape of orifice provided, and can cause great difficulties in cleaning the screen. In the

absence of, or to avoid the use of screens in such conditions, these problems were historically met by such means as gravity or pressure-induced deep bed filtration and batch, flocculation-induced settlement of solids in relatively simple mechanical systems.

More recently, filters have been developed for such conditions, using screens which are cleaned by one or more of several methods including scraping, suction, brushing and jet-spraying. These are usually dynamic systems, requiring relatively expensive, often quite complex, hydraulic and electro-mechanical engineering, which in turn require suitable maintenance and other support.

It is an object of the present invention to provide a filter with a longer work cycle which operates without clogging for a longer period than prior art filters.

A further object of the present invention is to provide a filter for conditions in which the biological material in the liquid to be filtered is particularly problematic.

Yet another object is to provide a filter embodying a static device which is technically simple and easy to make, convenient to operate and maintain and thereby cost-effective.

It is more specifically an object of the present invention to provide a filter in which turbulence is used in a controlled manner to assist cleaning of the filter screen during operation and during flushing. In this method, a volume reduction device of the kind described in U.S. Patent No.

4,966,701 having variations on its outer surface is provided. These variations may be protuberant and/or indented, in relief or with depth, continguous or continuous, regular or irregular in shape and distribution and in any number and configuration required to achieve the object of the invention and such modified TVRDs having textured turbulence-creating outer surfaces will be referred to hereinafter by the abbreviation "TVRD".

The incoming liquid stream flowing parallel to and between the filter screen and the TVRD interacts with the surface of the latter. The nature of the resulting turbulence is a function of the speed of flow and the configuration of the volume reduction device surface. While in most engineering applications surface roughness of flow channels is kept as low as possible, the present invention utilizes the known effect of surface roughness to deliberately create turbulent flow in the latter part of the filter. The turbulence will be less, or even non-existent, when water flow is relatively slow and much greater when flow is increased, e.g., during valve flushing. Furthermore, turbulence will depend on the degree of texturing at any particular point on the TVRD surface.

It will be understood that during filter operation and in the absence of flushing, maintenance of laminar, non-turbulent flow at the near end of the filter will enhance sweeping of retentions to its far end. This minimizes the possibility of local turbulence driving solids at the filter screen and possibly into or through the screen orifices.

Accordingly, in one embodiment of the invention, few or no surface irregularities are placed on the TVRD at the inflow end of the filter. However, such irregularities are gradually increased in number and/or

depth, though not necessarily at a constant rate, towards the far end of the TVRD. Thus, during filtering turbulence is gradually and slightly increased along the screen to balance the gradual decline in flow speed due to the outflow through the screen and much more increased during flushing, when speed of flow is both increased and maintained along the full length of the screen and the TVRD.

At the far end of the filter, there is an increased tendency for particle deposition on the screen due to an increasing concentration of solids at this location, and also to the more random movement of suspended solids that results from decreased speed of flow. Accordingly, at the far end of the filter increased turbulence becomes more of an advantage than a disadvantage, and here the TVRD has maximum surface changes. The result is to delay or prevent the tendency of retentions in "wash" filters to deposit first and foremost on the far end of the filter screen. This is particularly effective in conjunction with bleed discharge. During flushing, the TVRD causes a violent turbulence, particularly at the far end of the screen where the heaviest deposits are usually found.

The present invention achieves the above objectives by providing a clog-resistant filter for separating solids from liquids of the type wherein said liquid is passed from a filter inlet through a circular-section hollow filter element, said filter being provided with means for the discharge of collected solids during filter operation. The filter comprises:

a) a housing provided with an inlet for the liquid to be filtered and provided with a first outlet for filtrate and with a second outlet for liquid containing a high concentration of solids;

b) a hollow filter element insertable into said housing, the internal side of said filter element being in fluid connection with said inlet and the external side of said filter element being in fluid connection with said first outlet;

c) a volume reduction device inserted in said filter element and being of a size to occupy a major portion of the hollow of said filter element, said volume reduction device being provided with a textured turbulence-creating outer surface; and

d) a pressure-reduction device in fluid connection with said second outlet and provided with discharge means for solids and for the liquid in which they are entrained;

whereby solid particles reaching said second extremity are swept out into the pressure-reduction device and the filter may operate for extended periods without attention during which time clogging of the filter element is inhibited.

In a preferred embodiment of the present invention there is provided a filter wherein said textured turbulence-creating outer surface is configured to allow laminar flow near said first outlet and to cause a relative greater turbulent flow near said second outlet.

In a further preferred embodiment of the present invention said textured surface is adapted to cause turbulent flow along the whole length of said filter element during filter flushing.

In a first configuration of the present invention there is provided a filter wherein said textured surface has surface projections.

In a second configuration of the present invention there is provided a filter wherein said textured surface has surface indentations, and in a third configuration of the present invention there is provided a filter wherein said textured surface has a combination of both surface indentations and surface projections.

The hollow filter element used in the present invention can be a single unitary perforated element, or formed from a stack of filtering rings.

Yet further embodiments of the apparatus of the invention will be described hereinafter.

The present invention also provides for a four-step method of filtering solids from liquids, comprising the steps:

a) flowing a solid-entrained liquid into a narrow flow passage formed between a filter element and a volume reduction device having a textured turbulence-creating outer surface;

b) separating the solid constituent from said liquid by allowing said liquid to pass through said filter element while solid constituents are retained thereby;

c) discharging liquid passing through said filter element through a first outlet conduit; and

d) continually discharging at reduced pressure said solid constituents, together with a small quantity of entraining liquid through a second outlet.

In preferred embodiments of the present invention said method further comprises periodically discharging said solid constituents through a valve.

In another preferred embodiment of the present invention there is provided a method for filtering solids from liquids, comprising the steps:

a) flowing a solid-entrained liquid into a narrow flow passage formed between a filter element and a volume reduction device having a textured turbulence-creating outer surface;

b) separating the solid constituent from said liquid by allowing said liquid to pass through said filter element while solid constituents are retained thereby;

c) discharging liquid passing through said filter element through a first outlet conduit; and

d) periodically discharging said solid constituents through a valve.

The concentrated solution leaving the filter during continual or periodic flushing can be passed either to a drain or to a storage tank. The latter is advantageous when a contaminating fluid such as a fuel is being processed, and allows for inspection or analysis of the solid constituent, which is likely to provide indication of process variables requiring correction. Furthermore, in some usages the collected solid may have commercial value.

In one embodiment of the invention a discharge valve for entrained solids is powered by the pressure-reducing means in a hydraulically operated mechanism as described in U.S. Pat. no. 3,862,035, the teachings of which are incorporated herein by reference.

Discharge of liquid-entrained solids may be carried out continually and/or by periodic valve discharge, the shock of valve opening making a valuable contribution to dislodging cake from the surface of the filter element.

The invention will now be described in connection with certain preferred embodiments with reference to the following illustrative figures so that it may be more fully understood.

With specific reference now to the figures in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

In the drawings:

FIG. 1 is a cross-sectional elevational view of a preferred embodiment of the filter according to the invention;

FIG. 2 is a detail view of an embodiment arranged for organized turbulent flow;

FIG. 3 is a side view of a volume reduction device having regularly arranged projections and indentations;

FIG. 4 is a detail view of a TVRD provided with irregularly arranged indentations;

FIG. 5 is a side view of a TVDR with circumferential grooves; and

FIG. 6 is a side view of a TVDR having a helical groove.

There is seen in FIG. 1 a clog-resistant filter 10 for separating solids from liquids, of the type wherein a liquid is passed from a filter inlet 12 through a circular-section hollow filter element 14. Filter 10 is provided with means for the discharge of collected solids during filter operation. A housing 20, shown as a two-part assembly for convenience of access, is provided with an inlet 12 for the liquid to be filtered, with a first outlet 22 for filtrate and with a second outlet 24 for liquid containing a high concentration of solids.

A hollow filter element 14 removably assembled in housing has a first extremity 26 where liquid first contacts filter element and a second extremity 18 furthest from first extremity 26. The internal side of filter element 14 is in fluid connection with inlet 12. The external side of element 14 is in fluid connection with first outlet 22.

A volume reduction device 28 is inserted in the space inside the filter element 14, and is of a size and shape to occupy a major portion of said space. The outer surface of device 28 is provided with textured turbulence-creating projections 32.

Advantageously, said projections 32 are arranged to cause turbulent flow along the length of filter element 14 during filter flushing, when liquid flows through both outlet ports 22, 24, or through either port

22 or port 24 alone, such flow helping to dislodge cake 30 from the inner surface of the filter element 14.

As will be noted, there is provided, in this embodiment, a greater density of projections 32 at the downstream end of the TVRD, thereby creating a greater tendency to turbulence at said end 18.

A pressure-reduction device 34 such as that described in US Patent 3,862,035, the teachings of which are incorporated herein by reference, can be used in conjunction with the present invention, and such a device is attached in fluid connection with the second outlet 24, and is provided with discharge means for solids and for the liquid in which they are entrained.

As described in said patent, the device 34 has a discharge outlet 36. A sump 38 connected between second outlet 24 and the inlet 40 of pressure reducing device 34 may optionally be provided. A discharge valve 42 being hand or automatically operable is also connected to the second outlet 24.

In operation, solid particles reaching second extremity 18 are swept out into pressure-reduction device 34, or are discharged through valve 42, or are collected in sump 38. Consequently, the filter 10 may operate for extended periods without attention, during which time clogging of the filter element 14 is inhibited.

With reference to the rest of the figures, similar reference numerals have been used to identify similar parts.

Referring now to FIG. 2, there is seen a detail of a filter 44 similar to that described with reference to FIG. 1. At slower speeds of flow, the flow tends to be laminar. This laminar flow is beneficial in preventing large particles from being forced into, or through the filter element 52. At faster speeds of flow, turbulence is caused, particularly where there is a greater density of texturing. This is valuable in carrying solid particles for transfer through the second outlet port 24, seen in FIG. 1. The textured turbulence-creating projections 56 on the outer surface of the volume reduction body 58 are positioned and dimensioned to cause a designed, turbulent flow even near the second outlet port 24 where flow rates are naturally low during filter operation.

Seen in FIG. 3 is the textured surface on the volume reduction device 54 formed by both surface projections 62 and indentations 63, regularly arranged in both pattern and distribution along the length of the TVRD.

FIG. 4 illustrates the textured surface of the volume reduction body 66 formed by surface indentations 68, arranged in an irregular pattern.

Referring now to FIG. 5, there is depicted the textured surface on the TVRD 74 formed by a pattern of circumferential form 76.

Referring now to FIG. 6, there is seen the textured surface on TVRD 80 as formed by a pattern of helical form 82.

It will be evident to those skilled in the art that the invention is not limited to the details of the foregoing illustrative embodiments and that the present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof.

Thus, a given textured surface can be provided with projections, indentations or combinations thereof, said projections and/or indentations being regular or irregular in shape, size, pattern or distribution, and said projections can also be of helical or circumferential configuration in a manner complimentary to that shown with regard to the indentations shown in Figs. 5 and 6, to create regular and/or irregular turbulence, as desired.

The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

WHAT IS CLAIMED IS:

1. A clog-resistant filter for separating solids from liquids, of the type wherein said liquid is passed from a filter inlet through a circular-section hollow filter element, said filter being provided with means for the discharge of collected solids during filter operation, said filter comprising:

a) a housing provided with an inlet for the liquid to be filtered and provided with a first outlet for filtrate and with a second outlet for liquid containing a high concentration of solids;

b) a hollow filter element insertable into said housing, the internal side of said filter element being in fluid connection with said inlet and the external side of said filter element being in fluid connection with said first outlet;

c) a volume reduction device inserted in said filter element and being of a size and shape to occupy a major portion of the hollow of said filter element, said volume reduction device being provided with a textured turbulence-creating outer surface; and

d) a pressure-reduction device in fluid connection with said second outlet and provided with discharge means for solids and for the liquid in which they are entrained;

whereby solid particles reaching said second extremity are swept out into said pressure-reduction device and said filter may operate for extended

periods without attention during which time clogging of the filter element is inhibited.

2. A filter according to claim 1, wherein said textured turbluence-creating outer surface is configured to allow laminar flow near said first outlet and cause relatively greater turbulent flow near said second outlet.

3. A filter according to claim 1, wherein said textured surface has surface indentations.

4. A filter according to claim 1, wherein said textured surface has surface projections.

5. A filter according to claim 1, wherein said textured surface has a pattern of circumferential form.

6. A filter according to claim 1, wherein said textured surface has a pattern of helical form.

7. A filter according to claim 1, wherein said textured surface is adapted to cause turbulent flow along the whole length of said filter element during filter flushing.

8. A method for filtering solids from liquids, comprising the steps:

a) flowing a solid-entrained liquid into a narrow flow passage formed between a filter element and a volume reduction device having a textured turbulence-creating outer surface;

b) separating the solid constituent from said liquid by allowing said liquid to pass through said filter element while solid constituents are retained thereby;

c) discharging liquid passing through said filter element through a first outlet conduit; and

d) continually discharging at reduced pressure said solid constituents, together with a small quantity of entraining liquid through a second outlet.

9. A method according to claim 8, further comprising periodically discharging said solid constituents through a valve.

10. A method for filtering solids from liquids, comprising the steps:

a) flowing a solid-entrained liquid into a narrow flow passage formed between a filter element and a volume reduction device having a textured turbulence-creating outer surface;

b) separating the solid constituent from said liquid by allowing said liquid to pass through said filter element while solid constituents are retained thereby;

c) discharging liquid passing through said filter element through a first outlet conduit; and

d) periodically discharging said solid constituents through a valve.

Fig. 1

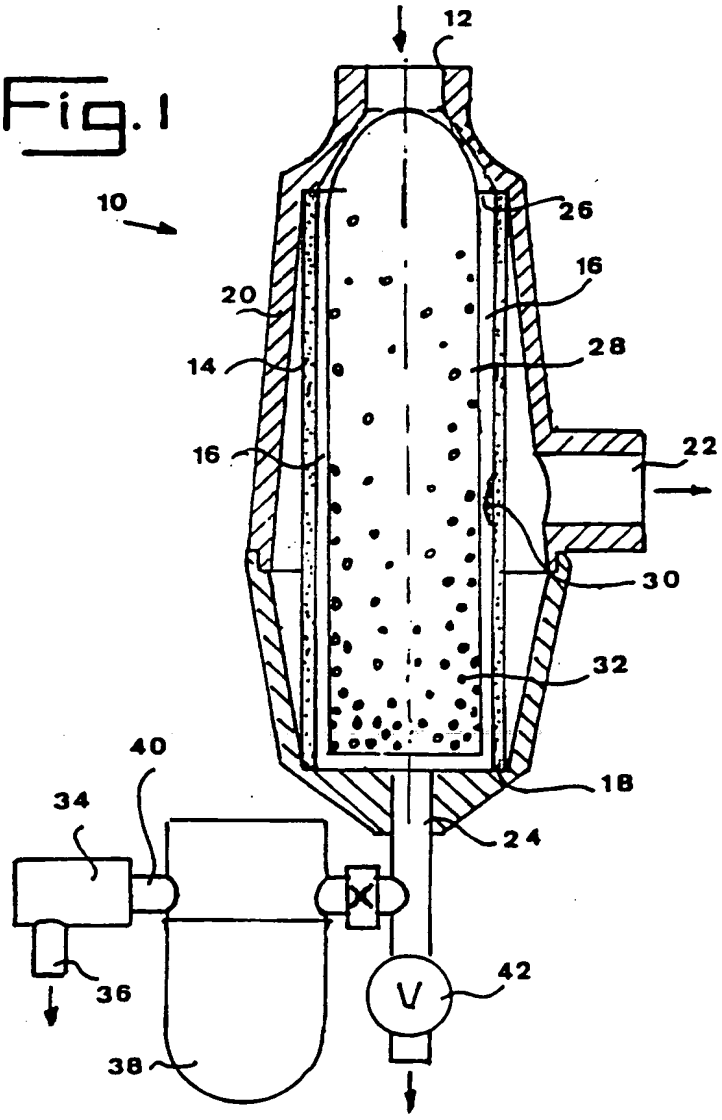


Fig. 2

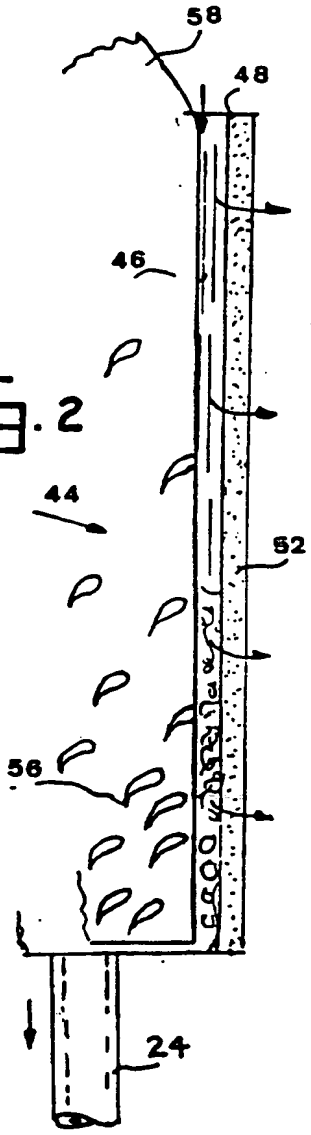


Fig. 3

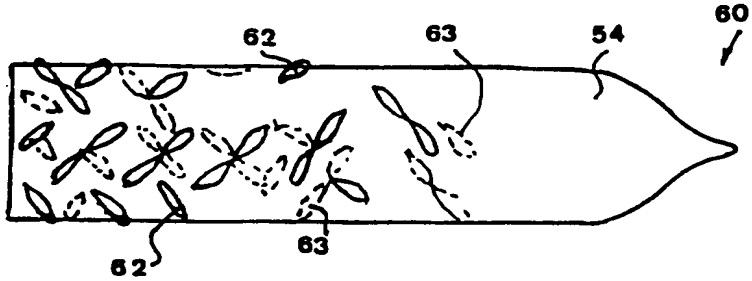


Fig. 4

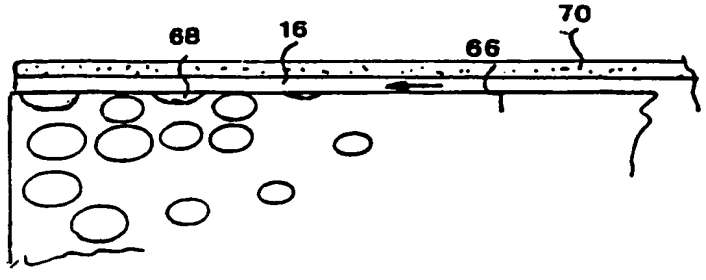


Fig.5

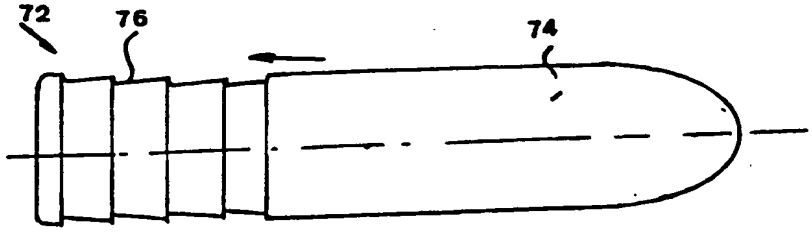
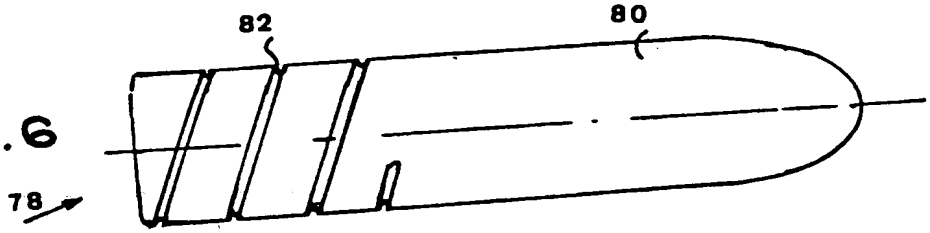


Fig.6



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/16197

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :B01D 29/94, 35/22
US CL :210/767, 304, 306, 308, 407, 456, 497.01
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 210/767, 304, 306, 308, 407, 456, 497.01

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3,898,157 A (HOOPER) 05 August 1975, see helical baffle (41) in fig. 1.	1,4,6-7, and 8
X	US 360,441 A (HOWES) 05 April 1887, see baffle f in fig. 1.	1 and 3-10
Y		2
Y	US 4,966,701 A (GOODMAN et al) 30 October 1990, see fig. 1.	2

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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